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(54) Title: STRETCH-ACTIVATED ELASTIC COMPOSITE		
(57) Abstract		
<p>A stretch-activated elastic composite (20A, 20B) comprising: a non-woven fabric (21, 22) having a potential elongatability of higher than 100 % in a predetermined direction, and an elastically recoverable, elastic sheet (11, 12). The elastic sheet in its unstretched state is partially bonded to the non-woven fabric in its unelongated state. The elastic composite exhibits, per unit width of 5 cm: a stress of lower than 1000 g at 30 % stretch; a stress of higher than 400 g at 100 % stretch; a breaking point of higher than 400 g and an elastic limit of higher than 200 %. The elastic composite after being stretched at a rate of lower than 200 % exhibits, per unit width of 5 cm: a stress of lower than 500 g at 30 % stretch and a stress of higher than 100 g at 100 % stretch. The elastic composite after three repeated cycles of 150 % stretching and relaxing exhibits an elastic recovery rate of higher than 60 %. The elastic composite of the present invention provides excellent performance in elastic recovery and a soft surface touch to a human skin, and is best utilized in elasticizing an article portion which is brought into direct contact with the human skin.</p>		

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STRETCH-ACTIVATED ELASTIC COMPOSITE

Field of the Invention

The present invention relates to an elastic composite which comprises a non-woven fabric and an elastic sheet, and which exhibits excellent performance in elastic recovery and a soft surface touch to a human skin. The elastic composite can be advantageously utilized in elasticizing an article portion which is brought into direct contact with the human skin during use, such as a sleeve portion of a medical gown, or a waist portion or a crotch portion of a sanitary article.

Background and Summary of the Invention

In recent years, disposable articles, including medical articles and sanitary articles, etc., have widely used elastic material to improve the fit to a human body. Particularly, infant articles utilize a composite of an elastic sheet and a non-woven fabric much more frequently than an individual use of an elastic sheet. The composite of the elastic sheet and the non-woven fabric is used expecting the elastic sheet to exhibit its elastic property and the non-woven fabric to provide improved surface structure and reinforcement of the elastic sheet.

A typical example of such an elastic composite is a three-layer composite called S.M.S. (spunbonded/meltblown/spunbonded) which is disclosed in U.S. Patents Nos. 4,663,220; 4,652,487; and 4,720,415. This composite is manufactured by a method called S.B.L. (Stretch-Bonded Laminate) wherein the elastic sheet is first stretched and is in its stretched state bonded to the non-woven fabric to form the composite upon release. The composite manufactured in accordance with this method has a stable range of elasticity and neither expands beyond the range nor breaks during a normal use since its expansion limit corresponds to its stretched range during manufacture. However, the composite disadvantageously uses more of the non-woven fabric than may be necessary and is bulky so that it is not well-suited for a high-speed commercial production.

Japanese Patent No. 4-281059 also discloses a method for directly entangling fibers into an elastic net, which is however costly. In order to remedy these drawbacks, an attempt (EPC No. 556,749) has been made to bond an elongatable non-woven fabric to an elastic film on line to form a composite of channel-like construction.

Japanese Utility Model No. 3-39509 discloses an elastic composite which is constructed by hydro-entangling a web comprising staple fibers and a non-woven fabric directly formed of thermoplastic elastomers. In order for the composite to have stretchability of higher than 70%, it is described that those staple fibers for constituting the web need to include fibers which slightly crimp upon application of heat or split fibers which split into fibers of finer than 1 denier.

The above conventional composites are capable of expanding over a wide range from a breaking point of the non-woven fabric to a breaking point of the elastic sheet. Their critical points however create difficulty in designing product and defining its specifications. It also leaves users with insufficient knowledge for proper use since they do not know at what point the composite breaks.

An object of the present invention is to provide a highly productive, economical and functional elastic composite which utilizes individual properties of a non-woven fabric and an elastic

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sheet in combination. Another object of the invention is to provide a method for manufacturing such an elastic composite.

In accordance with the present invention, there is provided a stretch-activated elastic composite which comprises a non-woven fabric having a potential elongatability of higher than 100% in a biased direction, and an elastic sheet having an elastic recovery rate of higher than 60% and an elastic limit of higher than 200%. The non-woven fabric in its unelongated state is partially bonded to one surface of the unstretched elastic sheet in securement regions. The elastic composite exhibits, per unit width of 5 cm, (1) a stress of lower than 1000 g at 30% stretch, (2) a stress of higher than 400 g at 100% stretch, (3) a breaking point of higher than 400 g., and (4) an elastic limit of higher than 200%. The elastic composite after being stretched less than 200% exhibits, per unit width of 5 cm, (1) a stress of lower than 500 g. at 30% stretch and (2) a stress of higher than 100 g. at 100% stretch. The elastic composite after three repeated cycles of 150% stretching and relaxing exhibits an elastic recovery rate of higher than 60%. "Strain" as used herein means the amount of elongation of the material when a stretching force is applied. "Stress" is the force applied to produce the strain.

In order to optimize the elastic composite structure in accordance with the present invention, it becomes important to combine respective characteristics of the non-woven fabric and the elastic sheet thereby improving their functions synergistically. Since the elastic sheet may be expensive relative to the non-woven fabric the addition of the non-woven fabric thereto further improves the cost/performance ratio of the elastic composite.

In accordance with the present invention, the designs of the expansible non-woven fabric and selections of the bonding method provide a wide range of selection of the elastic sheet and permit the elastic sheet to fully exhibit its desired functionality.

(1) The expansibility of the non-woven fabric enables the elastic composite which is not elastically stretchable in a normal condition to have the property that it is activated by expansion to become elastically stretchable and contractible.

(2) An expansible, hydro-entangled non-woven fabric is selected. A suitable selection of its entanglement condition enables the resulting non-woven fabric to have good expansibility as well as two-phase expansibility which creates a second increase in stress from a certain point.

(3) Securement regions for securing the elastic sheet to the non-woven fabric are provided to extend transversely to the expansible direction of the elastic composite so that the securement regions provide less resistance to the expansibility of the elastic composite.

(4) The securement regions provided between the non-woven fabric and a top surface of the elastic sheet are staggered from the securement regions provided between the non-woven fabric and a bottom surface of the elastic sheet to prevent those top and bottom securement regions from overlapping each other. This prevents creation of defective portions. Explaining further, where heat bonding is used some brittleness may occur where heat is applied. By staggering, as described, such brittleness which may be undesirable does not extend through the composite.

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The above considerations in designing the elastic composite construction enable production of the elastically recoverable, elastic composite which has excellent expansibility under low strain.

The present invention further provides a method for manufacturing an elastic composite having the above-described characteristics. This method will be now explained in detail with reference to the accompanying drawings.

Brief Description of the Drawings

Figure 1 is a graph showing S-S (stress-strain) curves of an elastic composite in accordance with the present invention.

Figure 2 is a graph showing S-S curves of another elastic composite in accordance with the present invention.

Figure 3 is a graph showing S-S curves of the elastic composite when stretched at a selected rate and released.

Figure 4 is a graph showing S-S curves of the elastic composite when stretched at a rate different from that of Figure 3 and released.

Figure 5 is a graph showing S-S curves of the elastic composite when stretched at a rate different from that of Figure 3 and released.

Figure 6 is a graph showing S-S curves of the elastic composite when stretched at a rate different from that of Figure 3 and released.

Figure 7 is a graph showing S-S curves of the elastic composite when stretched at a rate different from that of Figure 3 and released.

Figure 8 is a graph showing S-S curves of three different non-woven fabrics hydro-entangled by regular means when they are stretched both in MD (machine direction) and in CD (cross direction).

Figure 9 is a graph showing S-S curves of the non-woven fabric used in the present invention when stretched both in MD and in CD.

Figures 10A, 10B and 10C are schematic cross-sectional views respectively illustrating exemplary arrangements of the elastic sheet and the non-woven fabric in accordance with the present invention.

Figures 11A, 11B and 11C are representative plan views illustrating exemplary patterned provisions of intermittent securement regions in the elastic composite of the present invention.

Figures 12A, 12B and 12C are representative plan views illustrating exemplary arrangements of intermittent securement regions in the elastic composite of the present invention.

Figure 13 is a plan view illustrating an exemplary arrangement of intermittent securement regions in the elastic composite of the present invention.

Figure 14 is a plan view illustrating another exemplary arrangement of intermittent securement regions in the elastic composite of the present invention.

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Figure 15 is a plan view illustrating still another exemplary arrangement of an intermittent securement region in the elastic composite of the present invention.

Figure 16 is a graph showing results as measured with regard to the relationship between tensile strength of the elastic composite and process temperatures at which the elastic composite is heat-compressed.

Figure 17 is a perspective view illustrating an absorbent article which incorporates the elastic composite of Figure 13 as its side panel.

Figure 18 is a graph showing S-S curves of the elastic composite as prepared in Example 1, the elastic sheet and the non-woven fabric as used in preparing the elastic composite of Example 1, respectively, when they are stretched in CD.

Figures 19A, 19B and 19C are explanatory plan views illustrating surface structures after the second-stage treatment of Example 3, after the third-stage treatment and after the fourth-stage treatment, respectively.

Figure 20 is a graph showing results of a three-cycle test which repeats the 150% stretch and release of only the readily-stretchable portion of the elastic composite as prepared in Example 3.

Figure 21 is a graph showing results of a three-cycle test which repeats the 150% stretch and release of only the hardly-stretchable portion of the elastic composite as prepared in Example 3.

Detailed Description of Preferred Embodiments

First, explanation is made regarding stretch-activation. Figures 1 and 2 show typical S-S (strain-stress) curves of elastic composites in accordance with the present invention. Initial stretch of the elastic composite causes the elastic sheet and the non-woven fabric to experience their structure changes at the same time so that the elastic composite shows a relatively high stress. Once the elastic composite is initially stretched, the non-woven fabric has already elongated and exhibits slight resistance to a second stretch so that the elastic composite substantially exhibits the elastic characteristics of the elastic sheet at a second stretch, and similarly at a third stretch and stretches thereafter. The appearance of such a phenomenon will be referred to as stretch-activation in this specification.

Another important feature of the stretch-activation is that the elastic composite exhibits its elasticity within ranges depending upon stretching rates, as illustrated in Figures 3 through 7. Explaining further, Figs. 3-7, respectively, show S-S curves for an elastic composite similar to that depicted in Fig. 1, but with the maximum strain depicted being 50% (Fig. 3); 75% (Fig. 4); 100% (Fig. 5); 125% (Fig. 6) and 150% (Fig. 7). Accordingly, when the elastic composite is applied to a user's body, it elastically stretches and contracts within a range corresponding to movements of the user's body so that a flexible and efficient, fitting structure can be provided.

The stretch-activation, in some cases, might occur automatically when the elastic composite attached to a final product is stretched upon wearing. However, it may be desirable that such stretch-activation be done either prior to or during the production of a product using the composite. For instance, in an absorbent product using the elastic composite for a waist gather, the

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following two cases can be considered: (1) previously stretch-activated elastic composite is used; or (2) stretch-activation of the elastic composite is done during production process. In the former case, there can be a problem in storage and/or transportation of the material which becomes bulky. In the latter case this will be less of a problems. During the production of a product using the elastic composite which has not been previously stretch-activated a roll having deep corrugations or grooves in its peripheral surface may be used in the production line for achieving partial stretch in the elastic composite. In such case, attention needs to be paid to prevent damage to the surfaces of the non-woven fabric and elastic sheet.

Such a stretch-activated elastic composite preferably shows low stress and rapid increase in resistance as it exceeds a certain range of stretching rate so that it stops stretching before it breaks. In other words, such composite shows low resistance to stretching in the activated range but at the upper stretching limit it shows a rapid increase in resistance to stretching.

It is further important that the elastic composite maintains its elastic characteristics even after being stretched and released repeatedly. The important and basic characteristic of the elastic composite accordingly resides in its showing of low residual strain.

The characteristics of a preferred embodiment of the elastic composite of the invention now will be described.

The following results of measurements for physical characteristics were done according to methods commonly used in this field of industry and based on the JIS (Japanese Industrial Standards) standards. Major points of the measurements are given below:

(1) Samples to be tested

Width: 5 cm

Length: 15 cm

(2) Measurement condition for S-S curves

Chuck distance: 10 cm

Loading speed: 20 cm/min

(3) Cycle tests

Loading and unloading cycles are repeated three times at 150% stretch and the hysteresis curves are obtained. Stress values are read at 30% and 100% from the final returning point of the hysteresis curves. Between the cycles an ease time, in which all loading is released, is given, as shown below:

1st Measurement -- first 5 minute ease time -- 2nd Measurement --second 5 minute ease time -- 3rd Measurement -- third 5 minute ease time. The hysteresis curves as shown in Figs. 1 and 2 relate to this cycle. Line A shows the first loading cycle; A' shows the recovery during the first ease time; B shows the second loading cycle; B' the recovery during the second ease time; C the third loading cycle; and C' the recovery during the third ease time.

The elastic composite of 5 cm wide is sampled to measure a S-S curve during its first cycle of stretch and release which shows the following desirable characteristics.

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(1) Stress at 30% stretch

This shows the initial stress against stretch, which corresponds to the first expansion upon using. A 30% stretch is selected as an indicator, showing the initial stretch modulus, since it is commonly used in the fiber industry. This value should be selected carefully because too large an initial stress will create too tight a feeling. In experience, a desirable value is not more than 1,000 g, preferably 800 g and more preferably 600 g.

(2) Stress at 100% stretch

This is the stress necessary for stretch-activation, and may vary with the condition of usage or maximum degree of stretch upon using. In general, the elastic composite of the present invention displays its features at a highly stretched condition and will usually be used over 100% stretch, so that a stress at 100% stretch is selected for an evaluation point.

The elastic composite of this invention should have 400 g or more stress at 100% stretch, preferably 600 g, more preferably 800 g stretch in order to display the stretch-activated product, thereby achieving desirable stretch-activation by stretch at one time.

(3) Stress at a breaking point

A sufficient stress is usually 400 g or more, but security against accidental break down will be increased when the stress is higher than 600 g, because one can more easily feel the resistance approaching the limit of stretch.

Such elastic composite will have a very low measured stress value after stretch-activation. For example, after being stretch-activated at 150% stretch, the stress lower than 150% stretch will be significantly decreased. Such decrease in stress against stretch is desirable in view of the objectives of the usage of the composite of the present invention.

Desirable properties of an elastic composite of the present invention at 150% stretch at a second S-S curve measurement are given as follows:

(1) Stress at 30% stretch

The stress should be less than 500 g, preferably less than 400 g, and more preferably less than 300 g following stretch-activation. By selecting such value, potentially uncomfortably high compression on the body can be avoided when the elastic composite is used, for example, in products for infants.

(2) Stress at 100% stretch

After stretch-activation, the stress at 100% stretch will become significantly lower to make it easily stretchable, while providing a suitable resistance against stretch to provide a holding fit to the wearer. The minimum stress is higher than 100 g, preferably higher than 200 g.

A second S-S curve measurement shows the following characteristics.

(1) Stress at 30% stretch

Considering its conformability to a user, the stress is preferably less than 500 g, more preferably less than 400 g.

(2) Stress at 100% stretch

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The stress decreases by over 100 g, compared to the first measurement.

It is further important that the elastic composite exhibits a high elastic recovery rate, and accordingly a low residual strain value. In evaluating its performance in elastic recovery, the elastic recovery rate generally is measured after three repeated cycles of 150% stretch and release.

- 5 The elastic recovery ratio is determined by a review of the last returning point (P1) on a curve, such as shown in Fig. 2, against the starting point (P0) against the whole elastic ratio. For example, assuming the P1 point is at 30% for an elastic ratio of 100% the recovery ratio is calculated by the following formula:

$$\begin{aligned} 10 \quad \text{Recovery Ratio} &= \frac{100 - P1 - P0}{150} \times 100 \\ &= 100 - (30/150 \times 100) \\ &= 80 (\%) \end{aligned}$$

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The desirable elastic recovery rate is higher than 60%, preferably higher than 70%. Constituent elements of the elastic composite having such elastic recovery now will be explained.

- The elastic sheet to be used preferably is selected from materials having stretchability of higher than 20% and elastic recovery of higher than 60%. Materials having such characteristics
- 20 include foams such as of urethanes or rubber latexes; synthetic rubber films such as of isoprenes or butadienes; styrene-type elastomer films such as of SIS (styrene isoprene styrene), SEBS (styrene ethylene butadiene styrene), and SEPS (styrene ethylene propylene styrene); polyolefin elastomer films such as of EVA (ethyl vinyl acetate), EMA (ethyl methyl acrylate), and EPDM (ethylene propylene diene terpolymer); and meltblown elastomer non-wovens such as of polyurethane, SIS (styrene
- 25 isoprene styrene) and SEBS. The elastic sheet more preferably comprises a film, net-like formation, or meltblown non-woven, formed of heat-sealable styrene-type elastomers such as SIS or SEBS, or blend elastomers thereof.

The non-woven fabric, another constituent element of the elastic composite of the present invention, will be now explained.

- 30 The most suitable presently known non-woven fabric for use in the present invention is a hydro-entangled or spunlaced non-woven fabric, preferably having high elongatability in the machine direction (MD) or in the cross-direction (CD). The non-woven fabric having high CD-elongatability can be obtained by hydro-entangling a longitudinally oriented, parallel carded web which has a high MD/CD ratio, i.e. the fibers extend predominantly in the machine direction. The
- 35 non-woven fabric having high elongatability in MD can be obtained by hydro-entangling a randomly oriented fibrous web comprising highly shrinkable fibers, overfeeding the entangled web in MD and drying before it is treated to shrink.

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Such MD-elongatability or CD-elongatability is preferably higher than 100%, more preferably higher than 200%.

The elongatability of the non-woven fabric allows the non-woven fabric to follow the action of the elastic sheet when they are combined with each other.

- 5 The non-woven fabric has another important characteristic as well as its elongatability. As the elongation of the non-woven fabric exceeds a certain extent, the non-woven fabric starts showing resistance to further elongation thereof.

- 10 For comparison, Figure 8 shows exemplary CD and MD Stress-Strain (S-S) curves of three different non-woven fabrics noted Nos. 1, 3, and 5 which are respectively prepared by hydro-entangling normal parallel webs by conventional means. As apparent from Figure 8, these non-woven fabrics are highly elongatable in CD, and accordingly elongate easily in CD within elastic limits thereof. No resistance appears when each of the non-woven fabrics exceeds its elastic limit before it finally breaks.

- 15 In contrast, a spunlaced non-woven fabric (which also may be known as a "hydro-entangled non-woven" or a "water jet entangled non-woven") for use in the present invention shows rapid increase in stress at about 200% stretch as illustrated in Figure 9. With the stress maintained, the non-woven fabric continues to elongate until it breaks at a breaking point (about 260% stretch). This second-phase increase in stress at about 200% stress acts to resist breaking before the non-woven fabric finally breaks. It is desirable to select physical properties of the non-woven fabric so
20 that the second-phase increase in stress takes place preferably at higher than 150% stretch, more preferably at higher than 200% stretch.

In order for the non-woven fabric to exhibit such characteristics, the fibrous web construction and the condition for hydro-entanglement thereof need to be selectively combined. For example, the following non-woven fabric meets such requirements.

- 25 (1) Web construction

- Relatively short staple fibers of 25-45 mm long are mixed with relatively long staple fibers of 45-60 mm long to prepare raw staple fibers.

- Fibers are further mixed therein which are capable of shrinking to crimp.

- (2) Selection of condition for hydro-entanglement

- 30 Hydro-jets from fine nozzles integrally entangle fibers in the web construction over its whole area, and thereafter intensely hydro-entangle the web at transverse intervals. For example, three parallel rows of the nozzles are disposed to hydro-entangle the fibers in three stages.

A first stage nozzle diameter: 0.15 mm ϕ

nozzle pitch : 0.5 mm

- 35 water pressure : 30 kg/cm²

A second stage nozzle diameter: 0.15 mm ϕ

nozzle pitch : 0.5 mm

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water pressure : 50 kg/cm²

A third stage

nozzle diameter: 0.20 mm ϕ

nozzle pitch : 1.0 mm

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water pressure : 60 kg/cm²

A spun-laced non-woven fabric having a striped pattern is obtained under the above condition.

The elastic composite of the present invention comprises an elongatable non-woven fabric bonded to a top surface or to top and bottom surfaces of the elastic sheet. Although the bonding method is not limited to a specific one, different bonding methods may cause the resultant elastic composite to have different characteristics. Regardless of the selected bonding methods, the following factors become important:

(1) The non-woven fabric is bonded to the elastic sheet so that the readily elongatable direction of the non-woven fabric is brought into agreement with the readily stretchable direction of the elastic sheet.

(2) The bonding is made to form securement regions in a selected pattern so that it does not disturb effective elongation of the non-woven fabric and effective stretching of the elastic sheet. To this end, it is desirable that the securement regions are arranged to define as small in number and area as possible in the readily elongatable direction. Such bonding can be easily made by distributing securement regions preferably in the range of 90° ($\pm 10^\circ$) with respect to the readily elongatable direction of the non-woven fabric.

(3) When non-woven fabric is placed on opposite surfaces of the elastic sheet, the selective provisions of the securement regions respectively between the one non-woven fabric and the elastic sheet and between the other non-woven fabric and the elastic sheet greatly affect the elastic characteristics of the formed elastic composite. In the elastic composite constructions having the elastic sheet flanked between two non-woven fabrics, the elastic sheet may comprise one sheet of an elastic film of 50 μ m thick or two sheets of an elastic film of 25 μ m, supposing that the desirable thickness of the elastic sheet is selected to be 50 μ m. However, it should be recognized that 50 μ m is used as an example and other thicknesses may be used as well. Figures 10A, 10B, and 10C illustrate three typical alternative embodiments for combining the elastic sheet and the non-woven fabric.

In Fig. 10A two elastic sheets 11, 12 each having a thickness of 25 μ m are bonded at securement regions 3 to two non-woven fabric sheets 21, 22, respectively to form two elastic composites 20A, 20B which are placed onto and bonded to each other by bonding the two elastic sheets 11, 12 such as by hot pressing as in region 4.

In Fig. 10B two elastic sheets 11, 12 each having a thickness of 25 μ m are placed and bonded between the two non-woven fabrics 21, 22 through securement regions 3 such as by hot pressing.

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In Fig. 10C an elastic sheet 13 of 50 μ m thick is flanked, or enclosed, between two non-woven fabric sheets 21, 22 and bonded thereto at securement regions 3.

An S-S curve is measured for each of the constructions illustrated in Figures 10A, 10B, and 10C. Each construction is stretched by 100% and is subsequently released to measure a length of the construction for comparison with its initial length prior to stretching. Better elastic recoveries are observed in 10B than 10C, and in 10A than 10B respectively.

In Figure 10A, the securement regions 3 of a first set of the elastic sheet 11 and the non-woven fabric 21 are arranged to be staggered from the securement regions 3 of a second set of the elastic sheet 12 and the non-woven fabric 22 so as not to overlap each other. The securement regions 3 upon which tensile stress is concentrated are arranged in different locations between a top and a bottom of the elastic composite so that the formed elastic composite has a relatively high tensile strength.

The industrial process for combining two sheets of a relatively thin one-sided composite to form a both-sided composite also improves production efficiency. Especially when polystyrene-type elastomer films such as SIS or SEBS are used for the elastic sheet, the stable both-sided composite can be readily manufactured by simply placing the film surfaces of the two composites onto each other and hot-pressing them since those films are highly heat-bondable onto themselves. This greatly improves productivity and also provides a cost-saving result.

Concerning the patterned bonding of the elastic sheet and the non-woven fabric, both the elastic composite construction having the non-woven fabric securely placed upon one surface of the elastic sheet and the elastic composite construction having the non-woven fabrics securely placed upon respective top and bottom surfaces of the elastic sheet as illustrated in Figures 10A, 10B and 10C are illustrated to have the securement regions 3 which respectively extend in a band-like manner in a direction transversely to, preferably at angles of $90^\circ (\pm 10^\circ)$, with respect to the readily elongatable and stretchable direction of the non-woven fabric and the elastic sheet.

The band-like securement regions may secure the non-woven fabric and the elastic sheet entirely over a specified area. Alternatively, the band-like securement region may comprise a plurality of securement segments arranged in a row toward a selected direction, such as a plurality of dots or line segments distributed in a desirable patterned manner over the specified area.

Figures 11A, 11B and 11C illustrate typical examples of the patterned rows each comprising a group of securement segments arranged at intervals. In Figures 11A, each of the securement segments 31 comprises a relatively short line segment. The securement segments 31 are arranged at suitable intervals in rows extending in a direction substantially transversely to the readily stretchable direction of the elastic composite to define a plurality of rows 30 of securement segments extending in parallel to each other. In Figure 11B, each row 30 of securement segments comprises a plurality of securement segments 31 which each comprises a line segment and extends substantially transversely to a longitudinal direction of the row 30 of securement segments. In Figure 11C, each of

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the securement segments 31 is substantially Y-shaped, although it may have any selected shape as well as the illustrated shapes.

The elastic composite sacrifices the inherent expansibilities of these materials in the securement regions which secure the non-woven fabric to the elastic sheet so that it is rendered substantially inelastic in the securement regions. Accordingly, when the provisions of the rows 30 of securement segments are made to extend substantially transversely to the readily-stretchable direction as illustrated in Figures 11A, 11B, and 11C, such provisions greatly reduce the stretchability of the elastic composite in the direction parallel to the readily stretchable direction even if the materials themselves are highly stretchable in such direction, although they rarely affect the stretchability of the elastic composite in the readily stretchable direction. Substantially, the elastic composite constructions as illustrated in Figure 11 expand to a very slight extent in the longitudinal direction of the rows 30 of securement segments.

For instance, the elastic composite shows greatly reduced stretchability in the securement regions even when the non-woven fabric and the elastic sheet are combined by hydro-entanglement to provide such securement regions. In contrast to the elastic composite as described in Japanese Utility Model No. 3-39509, the elastic composite of the present invention thus stretches to a very slight degree in the regions where the non-woven fabric and the elastic sheet are tightly hydro-entangled.

However, the elastic composite expands freely in the readily expansible direction transversely to the rows 30 of securement segments until it reaches the elastic limit of the non-woven fabric. The elastic composite returns to its initial length when the tension is released prior to reaching the limit. On the other hand, as the elastic composite is further stretched beyond the elastic limit, the non-woven fabric undergoes permanent elongation and never returns to its initial length even after release of the tension, while the elastic sheet sustains its elasticity because its elastic limit is much higher than that of the non-woven fabric and returns to its initial length after release of the tension. When the elastic composite returns to its initial length upon release, the non-woven fabric becomes pouched between the neighboring rows of securement segments.

Once the non-woven fabric undergoes the permanent elongation, a smaller force is thereafter required to stretch the elastic composite in the readily stretchable direction than is required when it is initially stretched beyond the elastic limit of the non-woven fabric. This phenomenon typically defines the stretch-activation as mentioned above.

As will be appreciated from the above description, the elastic composite is more resistant to stretching in the direction that the securement regions or the rows of the securement segments extend than in the readily stretchable direction thereof. This means that the specifically selected provisions of the securement regions or the rows of the securement segments permit the elastic composite to have its stretchability generally in a desirable and specified direction even when it comprises the non-woven fabric and the elastic sheet stretchable in all directions.

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Figure 12A shows a substantially rectangular elastic composite comprising an elastic sheet and a non-woven fabric which are highly stretchable in both x and y directions, respectively. As illustrated in Figure 12B, the elastic composite includes peripheral areas B, C of suitable widths respectively extending along its four linear edges to enclose a central area A. Each of the peripheral areas has linear securement regions 3 which extend transversely to and inwardly from the respective linear periphery. The illustrated elastic composite is stretchable in any directions in the central area A, only in the x direction in the peripheral areas B, and only in the y direction in the peripheral areas C.

Figure 12C shows an elastic composite which includes end areas B extending along opposite ends of the elastic composite and an area D extending in the y direction along the y-directional centerline. Those areas have respective linear securement regions 3 extending in the y direction. The elastic composite further includes end areas E extending along opposite ends thereof. The end areas E have linear securement regions 3 which extend at an angle of about 45° from the respective linear peripheries. Accordingly, the elastic composite is highly stretchable in the x-direction in its areas B and D, and is stretchable in a slanting direction in the end areas E, normal to securement regions 3 in areas E.

Because the elastic composites of Figure 12B or C have selected areas stretchable only in the respectively specified directions, it can be advantageously used for an elastic topsheet or backsheet of a disposable diaper. In such an event, the end areas B, the end areas C, E and the central area A may serve as waist elastics, leg elastics surrounding leg holes and expansive elastics for elastically contracting and stretching over an area of the diaper. This enables one to selectively design desirable products which are capable of following any configurations.

Figure 13 shows still another elastic composite embodiment of the present invention. An elastic composite 100 is stretchable only in one direction. The elastic composite is highly stretchable in its first central area 110 and is less stretchable or only slightly stretchable in its second opposite end areas 111. The elastic composite with such characteristics can be obtained by applying further bonding treatment such as partially heat-compressive treatment to the elastic composite as prepared in the above-mentioned manner.

In Figure 14, an elastic composite has three slightly-stretchable band-like areas 111 disposed at regular intervals.

An elastic composite of Figure 15 has highly-stretchable areas 110 on opposite sides of a slightly-stretchable band-like area 111. In these illustrated embodiments, the elastic composites comprise an elastic sheet and a non-woven fabric which are both formed of readily heat-fusible materials.

Examples of non-woven fabrics suitable for such requirement includes one comprising conjugate fibers consisting of a polyester core covered with polyethylene sheath, which is combined with a film of S.E.B.S. (styrene-ethylene-butadiene-styrene block polymer) as an elastic sheet. This

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material has good properties of sealability by ultrasonic and heat sealing, and can be used in a high speed production process.

The elastic composites having a highly-stretchable area 110 and a slightly stretchable area 111 as illustrated in Figures 13 through 15 can be obtained by applying heat of suitable temperature range to the area 111.

Figure 16 is a graph showing the results measured with regard to a relationship between tensile strength of an elastic composite and temperatures at which the elastic composite is heat-compressed. The elastic composite is prepared by placing an elastic sheet formed of SIS-type film upon a hydro-entangled non-woven fabric comprising PET (polyester) fibers and thereafter partially heat-compressing them for integration. The characteristics of the elastic composite illustrated in Fig. 16 are obtained by further applying heat and compression to the integrated elastic composite.

In the graph, T1 indicates the temperature at which SIS present in the elastic sheet starts to melt and T2 the temperature at which PET present in the non-woven fabric starts to melt, respectively. As can be seen from Figure 16, heat-compression below T1 is not sufficient to integrate the elastic sheet and the non-woven fabric so that the elastic composite exhibits low values of tensile strength while sustaining good elastic recovery. When the heat-compression is applied to the elastic composite at a temperature ranging from T1 to T2, at least a part of the elastic sheet melts and is fused to the non-woven fabric so that the elastic composite exhibits greatly enhanced tensile strength while its showing of elastic recovery disappears. The heat-compression above T2 causes the elastic sheet and the non-woven fabric to be fusively bonded to each other so that the elastic composite exhibits reduced stretchability in all directions.

Referring again to Figures 13 and 15, the elastic composites of those characteristics also can be obtained by utilizing different heat-compressive conditions in between the area 110 and the area 111 when heat-bonding the elastic sheet and the non-woven fabric which are placed upon each other so as to be stretchable in the same direction. Specifically, the elastic sheet and the non-woven fabric are partially heat-compressed in the area 110 at a temperature ranging between T1 and T2 and are entirely heat compressed in the area 111 at a temperature above T1 to render the areas 110 highly-stretchable and the area 111 slightly stretchable. The desirable stretchability can be given to the elastic composite in such a manner. Because the stretchability of the highly-stretchable area 110 is controlled or restrained by the presence of the slightly-stretchable area 111, the elastic composite is characteristically highly stretchable in a specified direction and is very slightly stretchable in the other directions.

Such elastic composites having highly-stretchable and slightly-stretchable areas disposed in mixed and patterned manner can be applied to various uses. For example, the elastic composite having the slightly-stretchable areas 111 disposed on opposite sides of the highly-stretchable area 110 such as illustrated in Figure 13 can be applied to tapeless (pant-type) absorbent articles.

Figures 17 illustrates an absorbent article, such as a tapeless diaper, or training pant, having a main body 121 comprising an absorbent body interposed between a liquid permeable

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- topsheet and a liquid impermeable backsheet. The main body is bent along its center line to define a substantially U-shaped configuration. An elastic composite 100 connects opposite side edges of the U-shaped main body to define a leg hole 122. The elastic composite 100 has the slightly-stretchable, opposite end areas 111 connected to the main body 121 and the highly-stretchable central area 110 rendered free, so that the highly-stretchable characteristics of the area 110 is not disturbed. The elastic composite 100 is connected at its opposite ends to the main body 121 to serve as a side panel of the diaper or training pants.

Examples of the present invention will be now described.

Example 1.

10 Manufacture of an elongatable non-woven fabric -

50 parts of polyester fibers (1/5 denier x 35 mm) is mixed with 50 parts of polyester fibers (2 denier x 51 mm). The mixture is introduced into a roller card to prepare a parallel carded web having a basis weight of 25 g/m².

- The web has an orientation ratio MD/CD of 7. In other words, the strength of the web in the machine direction (MD) is seven times its strength in the cross direction (CD). The web is introduced over a porous suction cylinder provided with a dewatering zone while subjected to water-saturation, degassing and dewatering. The web then is passed at a running speed of 30 m/min under three banks of water nozzles for water-entanglement.

- 20 A first nozzle: 0.12 mm diameter x 0.4 mm pitch (distance between adjacent water pressure 30 kg/cm² nozzles in a bank)
- A second nozzle: 0.12 mm diameter x 0.4 mm pitch water pressure 50 kg/cm²
- A third nozzle: 0.20 mm diameter x 1.5 mm pitch water pressure 60 kg/cm²

- 25 The entangled web as described above is dried and subsequently is subjected to heat treatment so that a web-form non-woven fabric having a basis weight of 30 g/m² is obtained.

An S-S curve of this non-woven fabric when stretched in CD is indicated at A in Figure 18.

Preparation of an elastic sheet -

- 30 A blend resin comprising EMA/EPDM (ethyl methyl acrylate/ethylene propylene diene terpolymer) polyolefin elastomer is extruded to form a film of 25 μ thick. A S-S curve of this elastic sheet when stretched in CD is indicated at B in Figure 18.

One-sided composite -

- 35 The elastic sheet and the non-woven fabric as prepared above are placed upon each other prior to introduction thereof over a 60-mesh PET net the elastic sheet side facing toward the PET net. A heat roll having patterned annular grooves thereon is disposed over of the non-woven side and is heated to 130°C. A flat or non-grooved roll is disposed beneath the PET net. The heat

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roll is pressed against the elastic sheet and fabric so they are compressed against the flat roll at a line pressure of 10 kg/cm to form an elastic composite.

An S-S curve of the elastic composite thus produced when stretched in CD is indicated at C in Figure 18.

- 5 A three-cycle test which repeats the 150% stretch and release of the elastic composite provides results as shown in Figure 1. A measured recovery rate is 75%.

Both-sided composite -

- Two sheets of the above elastic composite are placed upon each other so that their film sides face toward each other. A non-grooved surface heat roll as heated up to 80° C is employed to
10 apply pressure to the sheets at a line pressure of 20 kg/cm and at a speed of 10 m/min so that a stable bonding condition is provided between the facing film sides of the two sheets. The securement regions in top and bottom sides are staggered from each other so as not to overlap each other. A S-S curve of the resulting elastic composite is indicated by D in Figure 18.

- A three-cycle test which repeats the 150% stretch and release of this elastic composite
15 provides results as shown in Figure 2. A measured recovery rate is 75%.

Example 2

One-sided composite comprising a SEBS-type film and a non-woven fabric -

- A composition primarily constituted by a resin comprising a mixture of 75 parts SEBS and 25 parts EVA is extruded to prepare an elastic film of 25 μ thick. Characteristically, this film
20 can be easily bonded onto itself by compression at room temperature.

A slight amount (about 0.4 g/m²) of rubber-type hotmelt adhesive is sprayed onto one surface of the film which then is bonded over its entire surface to a non-woven fabric as similar to the one prepared in Example 1 by heat-compression.

Both-sided composite -

- 25 Two sheets of the above elastic composite having the non-woven fabric secured on one side of the SEBS-type film are placed upon each other so that their respective film sides face toward each other. These two sheets are passed between a pair of non-grooved rolls at a temperature of about 40°C and under a line pressure of 20 kg/cm² to provide a two-sided composite which has the non-woven fabrics in its opposite sides and films stably secured to each other.

- 30 The one-sided and two-sided composites thus constructed show elastic recoveries as similar to those of Example 1.

Example 3

- 70 parts of polypropylene fibers (2 denier x 30 mm) is mixed with 30 parts of polyester fibers (2 denier x 57 mm). The mixture is introduced into a roller card to prepare a parallel carded
35 web having a basis weight of 20 g/m². The web has a MD/CD ratio of 8.0.

The web is introduced over a net conveyor where it is placed upon a melt-blown non-woven fabric (manufactured by KURARAY Co., Ltd.) primarily constituted of SIS and having a basis weight of 40 g/m². The combined web and non-woven fabric are then introduced over a net

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provided with nozzles and a dewatering zone where they are subjected to multi-stage hydro-entanglement treatments as shown in the following Table 1.

Table 1

Stage	Nozzle spec.	Pressure	Surface appearance of the obtained elastic composite
First stage (provisional stage)	0.12 mm \times 0.6 mm	30 kg/cm ²	---
Second stage (provisional stage)	0.12 mm \times 0.6 mm	50 kg/cm ²	Figure 19A
Third stage (partial entanglement)	0.20 mm \times 4.0 mm	100 kg/cm ²	Figure 19B
Fourth stage (partially inelasticizing treatment)	0.15 mm \times 0.6 mm	80 kg/cm ²	Figure 19C

15

The surface structures of the composites obtained at stages are shown in Figures 19A, 19B and 19C. The entangled elastic composite after the final stage has band-like readily-stretchable portions 131 and hardly-stretchable portions 132. A three-cycle test which repeats the 150% stretch and release of only the readily-stretchable portion 131 of the elastic composite provides results as shown in Figure 20. A measured recovery rate is 70%. On the other hand, the hardly stretchable portion 132 hardly contracts elastically and provides a S-S curve as shown in Figure 21. Its breaking point is shown to be 1.2 kg/50 mm.

As described above, the elastic composite in accordance with the present invention comprises a non-woven fabric which is potentially elongatable by higher than 100% in a specific direction, and an elastically recoverable elastic sheet. The non-woven fabric in its unelongated state is bonded to at least one surface of the unstretched elastic sheet through securement points to form the elastic composite which has a recovery rate of higher than 60% after experiencing the three-repeated cycles of 150% stretch and release. Therefore, the elastic composite of the present invention provides excellent performance in elastic recovery and a soft surface touch to a human skin. In particular, the elastic composite of the present invention can be advantageously utilized in elasticizing an article portion which is brought into direct contact with the human skin, such as a sleeve portion of a medical gown, a waist portion or a crotch portion of a sanitary article.

Although various embodiments of the invention have been described herein it will be recognized that variations and modifications are possible without departing from the spirit of the invention as set out in the claims.

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Claims

1. A stretch-activated elastic composite comprising:
a non-woven fabric sheet adapted to be elongated by more than 100% in one direction;
and
5 an elastically recoverable, elastic sheet;
said elastic sheet in its unstretched state being bonded at securement regions to one surface of said non-woven fabric sheet in its unelongated state;
said elastic composite having, per unit width of 5 cm, when stretched in said one direction (1) a stress of lower than 1000 g at 30% stretch, (2) a stress of higher than 400 g at 100% stretch, (3) a breaking point of higher than 400 g, and (4) an elastic limit of higher than 200%,
10 said elastic composite after being stretched to an elongation of less than 200% having, per unit width of 5 cm, (1) a stress of lower than 500 g at 30% stretch and (2) a stress of higher than 100 g at 100% stretch, and
said elastic composite after three repeated cycles of 150% stretching and relaxing having
15 an elastic recovery rate of higher than 60%.
2. The elastic composite of claim 1, which further comprises a second non-woven fabric sheet and wherein the first-mentioned and second non-woven fabric sheets are bonded to opposite surfaces of said elastic sheet.
3. The elastic composite of claim 2, which further comprises a second elastic sheet and
20 wherein the first-mentioned and second elastic sheets each have a first surface and an opposed second surface, said first-mentioned fabric sheet is bonded at securement regions to the first surface of the first-mentioned elastic sheet, said second non-woven sheet is bonded at securement regions to the first surface of the second elastic sheet, and the second surfaces of said elastic sheets are bonded to each other.
4. The elastic composite of claim 3 wherein
25 securement regions between said first fabric sheet and said first-mentioned elastic sheet are offset from the securement regions between said second fabric sheet and said second elastic sheet.
5. The elastic composite of claim 1 wherein
30 the securement region which bonds said elastic sheet and said woven fabric extends in an elongate band in a direction extending transversely of said one direction.
6. The elastic composite of claim 1 wherein
said securement regions which bond said elastic sheet and said non-woven fabric are arranged in rows which extend in a direction transversely of said one direction
7. The elastic composite of claim 1 wherein
35 said non-woven fabric comprises a fabric produced by water-entanglement and having a two-phase expansibility at different stress levels.
8. The elastic composite of claim 7, wherein

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said non-woven fabric comprises a fabric whose elongation at a second phase takes place at an elongation rate of higher than 150%.

9. The elastic composite of claim 1 wherein said elastic sheet comprises heat-fusible material.

5 10. The elastic composite of claim 9, wherein said elastic sheet and said non-woven fabric are, in a specified area of the elastic composite, bonded to each other by heat compression above the temperature at which the elastic sheet starts to melt but below the temperature at which the non-woven fabric starts to melt to form a slightly-stretchable portion which is more resistant to stretching than the remaining portions so that the elastic composite has a specified stretchable
10 direction.

11. The elastic composite of claim 10, wherein said slightly-stretchable portion is provided in a band-like manner.

12. The elastic composite of claim 9, wherein said non-woven fabric consists of conjugate fibers which are easily fusible by heat.

15 13. An elastic composite comprising an elastic sheet and a non-woven fabric, said elastic composite including a highly-stretchable area which is constructed by partially bonding said elastic sheet to said non-woven fabric and a slightly-stretchable area which is constructed by substantially entirely bonding said elastic sheet to said non-woven fabric.

20 14. The elastic composite of claim 13 wherein said slightly-stretchable area comprises a plurality of band-like securement regions between said fabric and elastic sheet extending parallel to each other.

15. The elastic composite of claim 13, wherein said elastic composite includes said slightly-stretchable portions adjacent its opposite ends.

25 16. A stretch-activated elastic composite comprising:
a non-woven fabric having a potential elongatability of higher than 100% in one direction; and an elastically recoverable, elastic sheet;

said elastic sheet in its unstretched state being bonded to at least one surface of said non-woven fabric in its unelongated state at securement points,

30 said elastic composite having, per unit width of 5 cm, (1) a stress of lower than 800 g at 30% stretch, (2) a stress of higher than 600 g at 100% stretch, (3) a breaking point of higher than 400 g, and (4) an elastic limit of higher than 200%,

said elastic composite after being stretched at a rate of lower than 200% having, per unit width of 5 cm, (1) a stress of lower than 300 g at 30% stretch and (2) a stress of higher than 200
35 g at 100% stretch, and

said elastic composite after three repeated cycles of 150% stretching and relaxing having an elastic recovery rate of higher than 60%.

17. A disposable absorbent garment comprising:

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an absorbent body portion having a substantially U-shaped configuration to conform to the crotch region of a wearer with opposed front and rear end portions adapted to be disposed adjacent the front and back of the wearer and having opposed side edges, and

5 a side panel interconnecting adjacent side edges of the front and rear end portions, said side panel being an elastic composite including an elastic sheet and a non-woven fabric, said composite including a highly-stretchable area which is constructed by partially bonding said elastic sheet to said non-woven fabric and a slightly-stretchable area which is constructed by substantially entirely bonding said elastic sheet to said non-woven fabric, said slightly stretchable area being much less stretchable than said highly-stretchable area.

10 18. The garment of claim 17, wherein said slightly-stretchable area comprises a plurality of band-like securement regions between said fabric and elastic sheet extending parallel to each other.

19. A stretch-activated elastic composite comprising:

a non-woven fabric sheet adapted to be elongated by more than 100% in one direction;

15 and

an elastic sheet having an elastic recovery rate of higher than 60% and an elastic limit of higher than 200%;

said elastic sheet in its unstretched state being bonded at securement regions to one surface of said non-woven fabric sheet in its unelongated state;

20 said elastic composite having, per unit width of 5 cm, when stretched in said one direction (1) a stress of lower than 1000 g at 30% stretch, (2) a stress of higher than 400 g at 100% stretch, (3) a breaking point of higher than 400 g, and (4) an elastic limit of higher than 200%,

said elastic composite after being stretched to an elongation of less than 200% having, per unit width of 5 cm, (1) a stress of lower than 500 g at 30% stretch and (2) a stress of higher than 100 g at 100% stretch, and

25 said elastic composite after three repeated cycles of 150% stretching and relaxing having an elastic recovery rate of higher than 60%.

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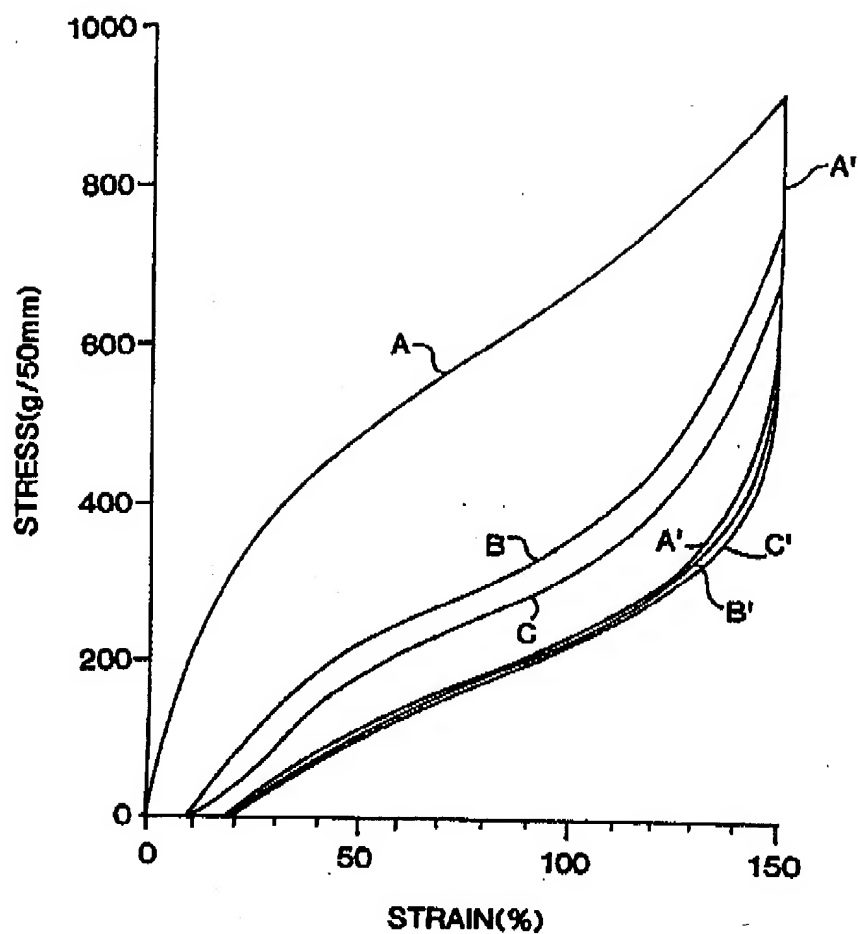


FIG. 1

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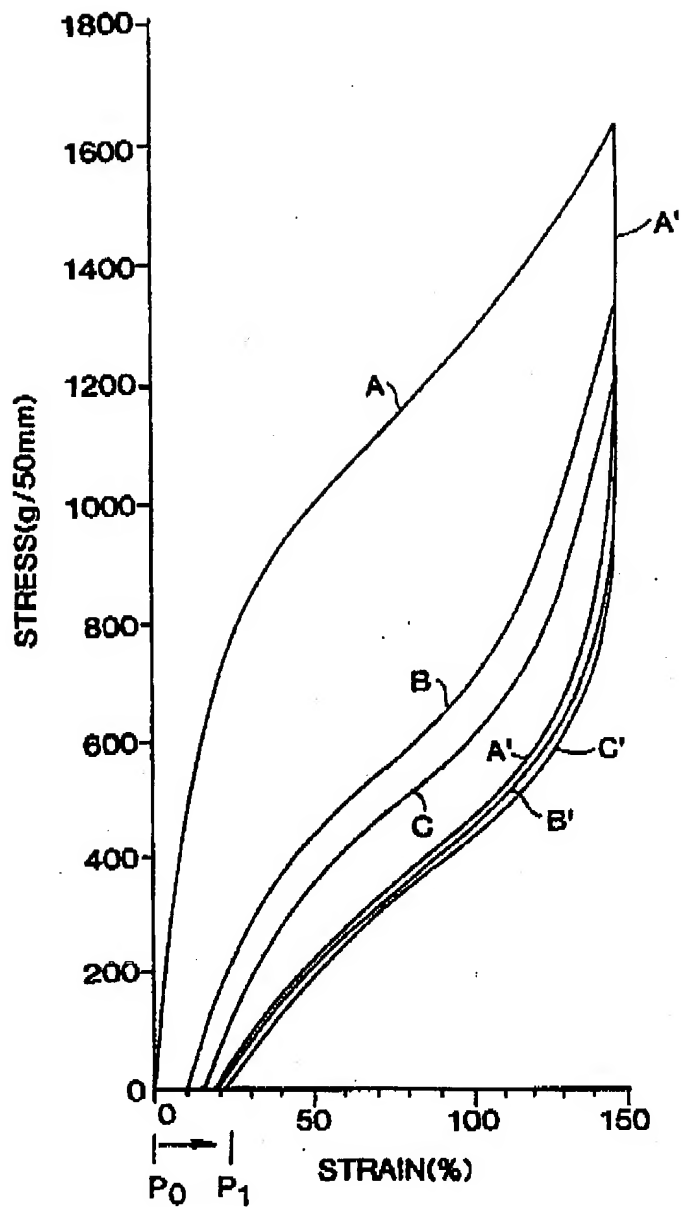


FIG. 2

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FIG. 3

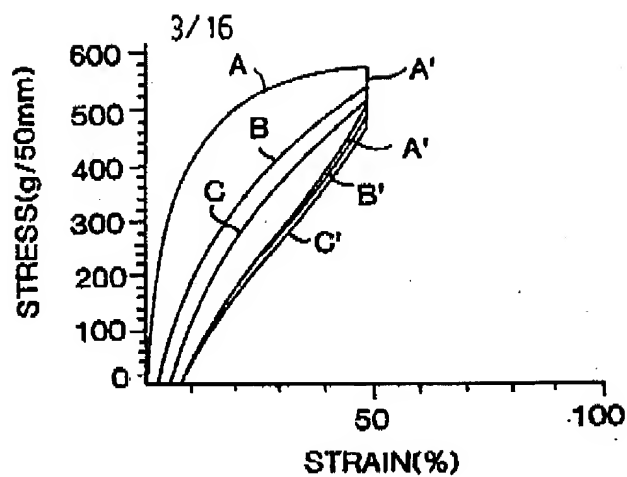


FIG. 4

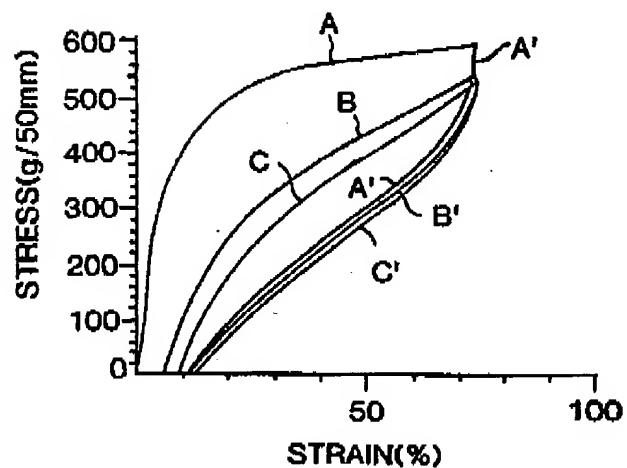
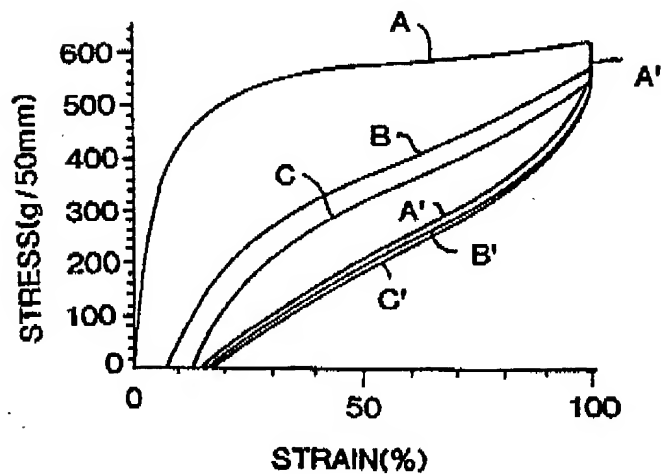


FIG. 5



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FIG. 6

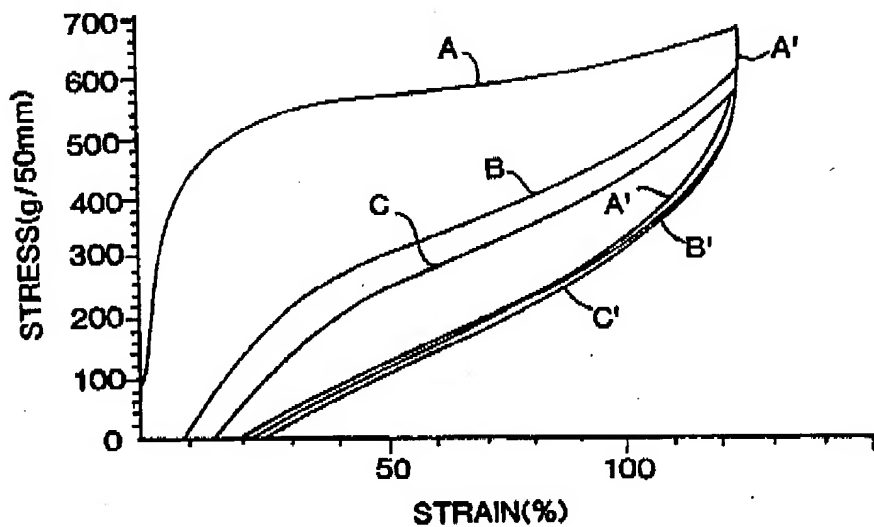
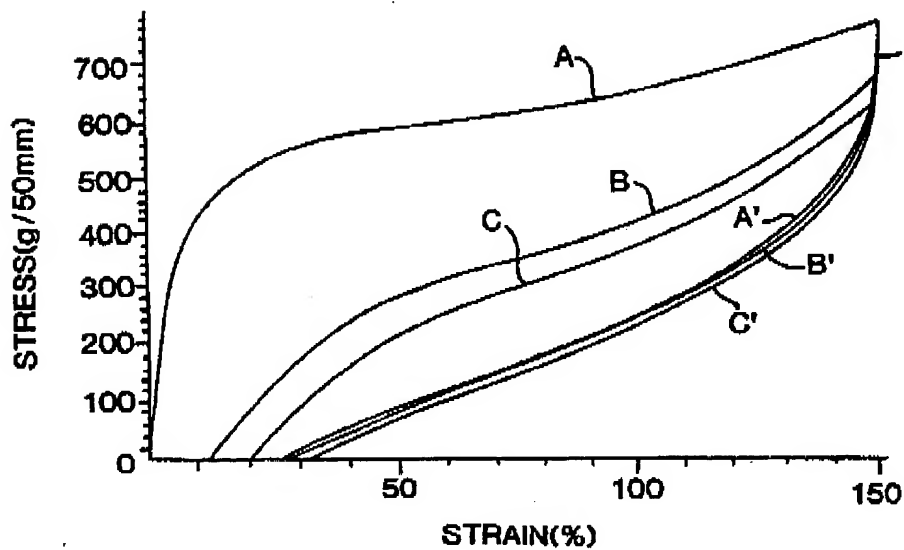


FIG. 7



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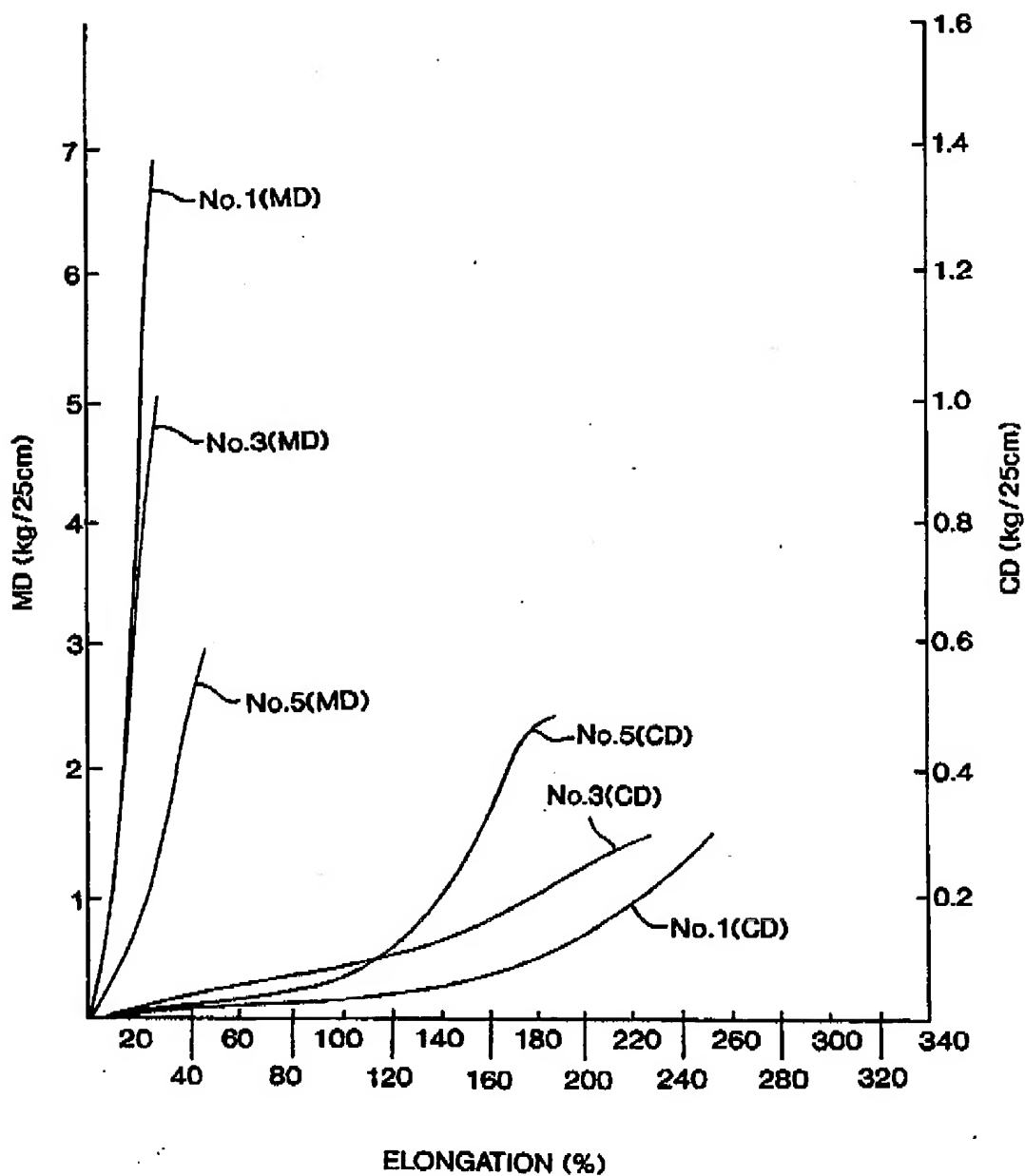


FIG. 8

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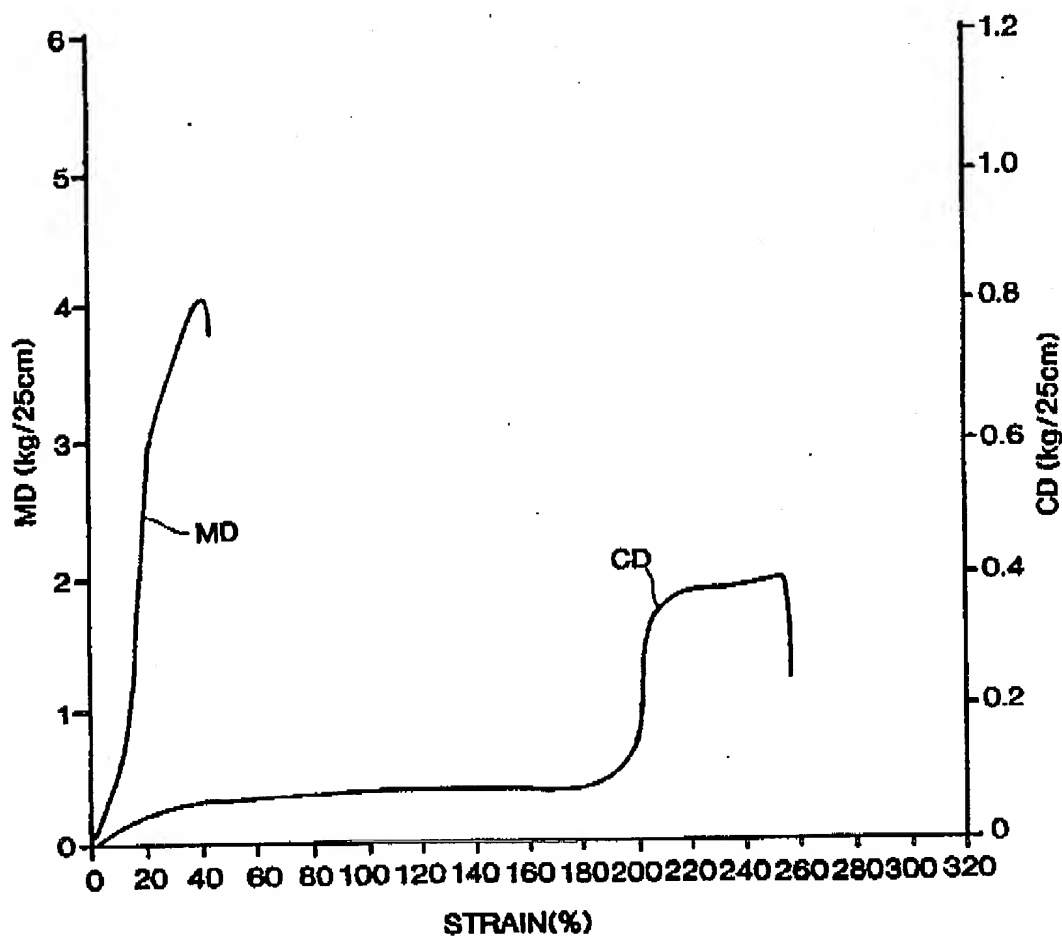


FIG. 9

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FIG. 10A

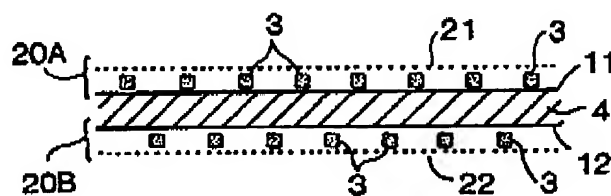


FIG. 10B

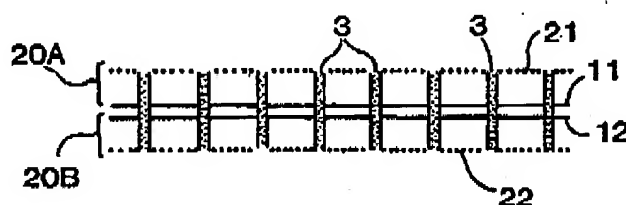
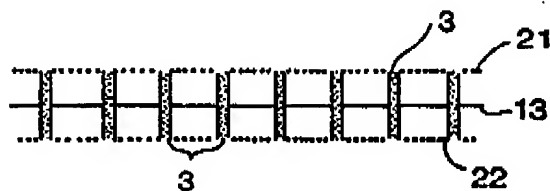


FIG. 10C



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FIG. 11A

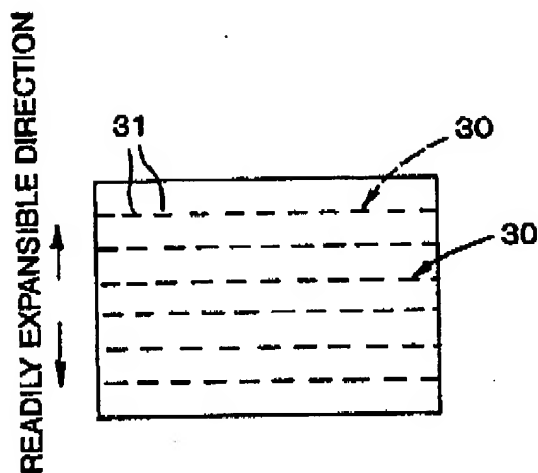


FIG. 11B

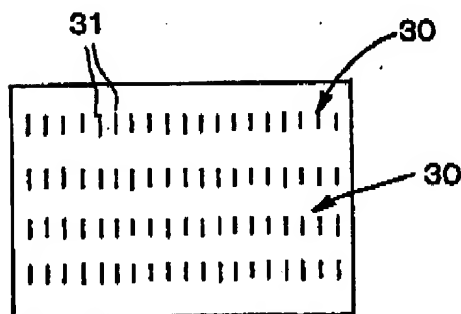
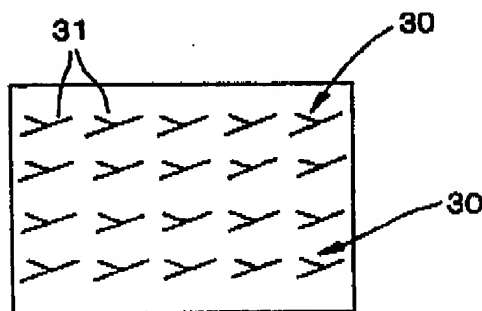


FIG. 11C



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FIG. 12A

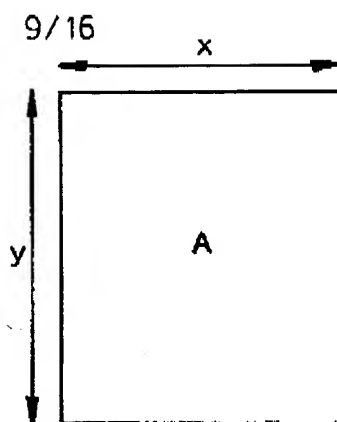


FIG. 12B

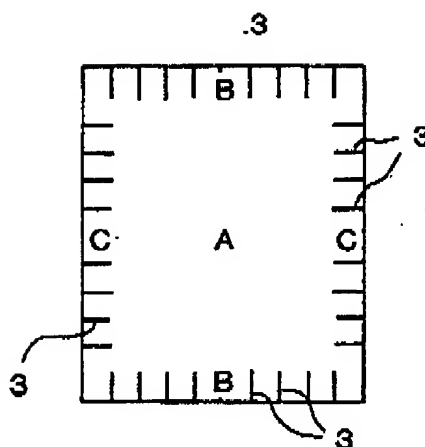
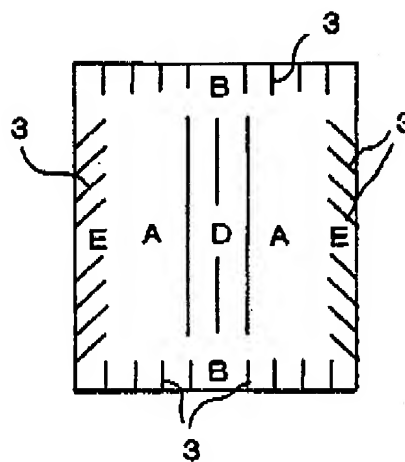


FIG. 12C



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FIG. 13

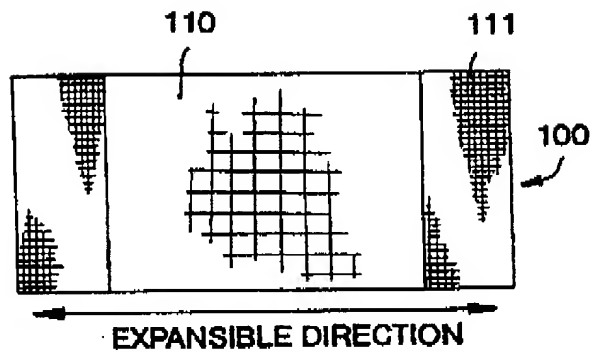


FIG. 14

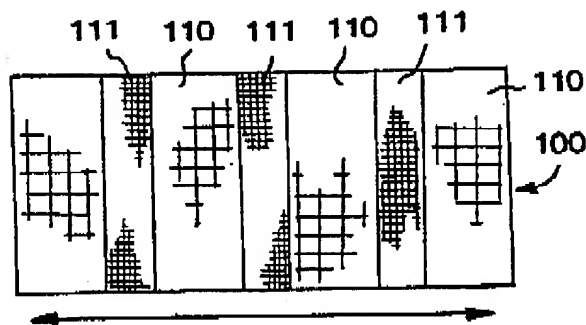
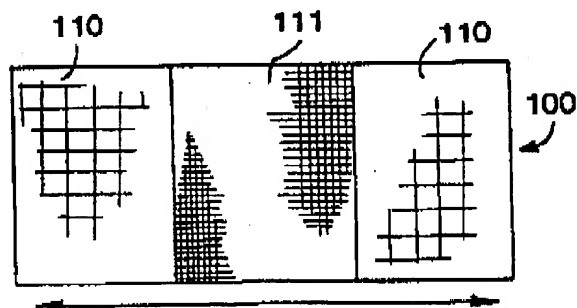


FIG. 15



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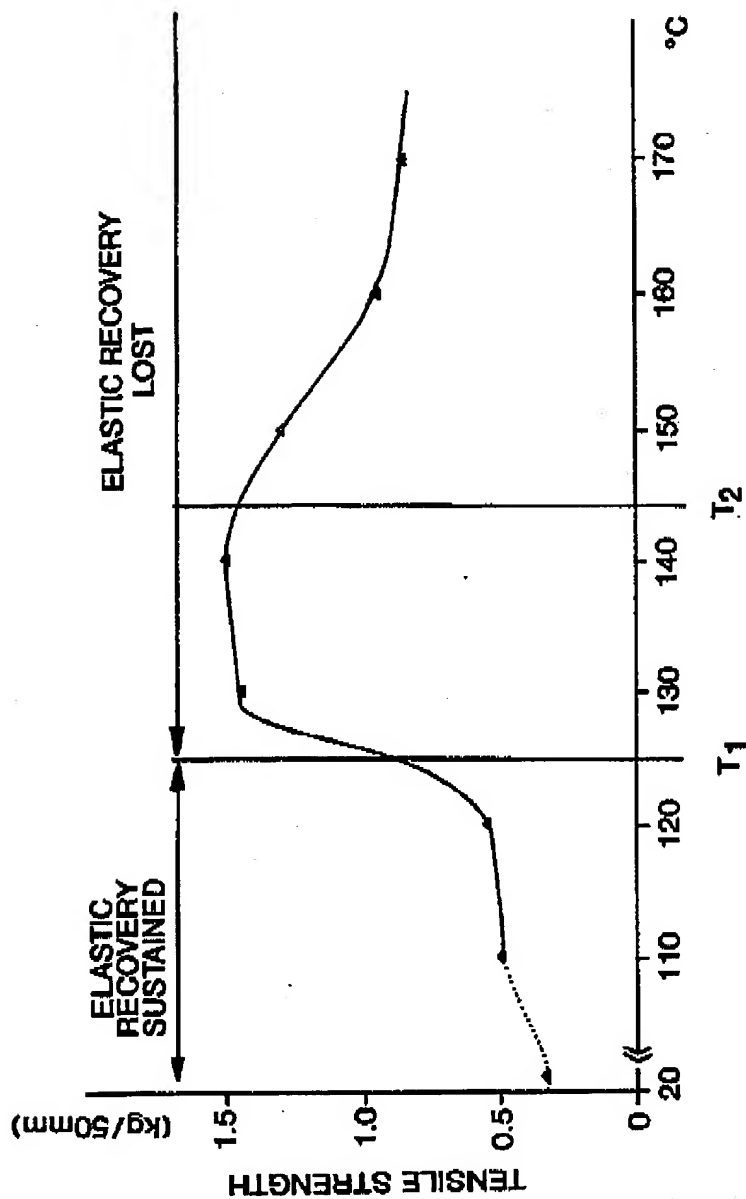


FIG. 16

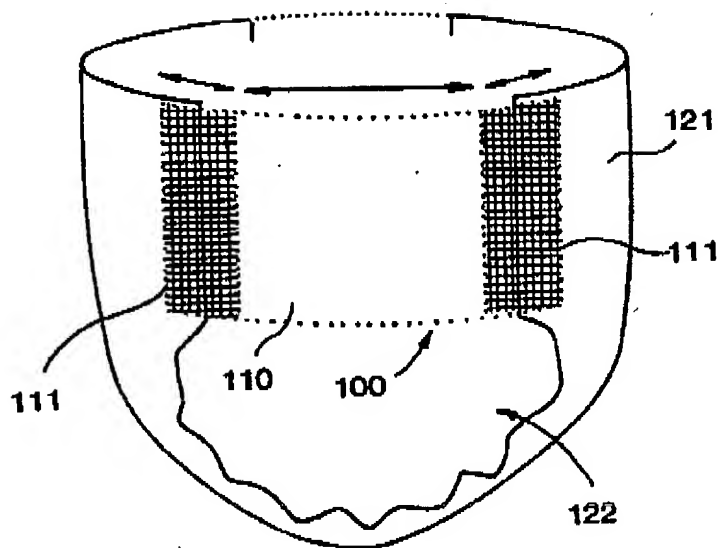
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FIG. 17

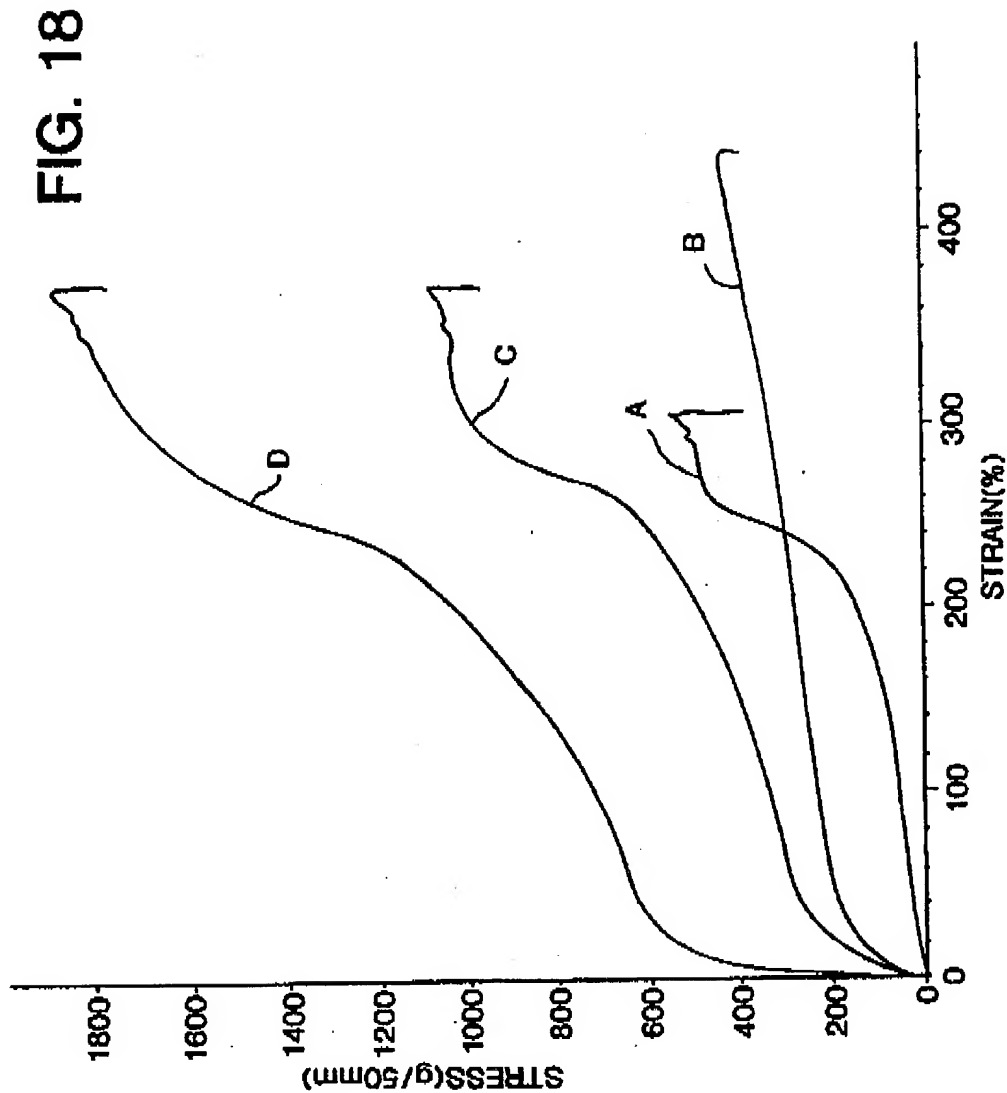


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FIG. 19A

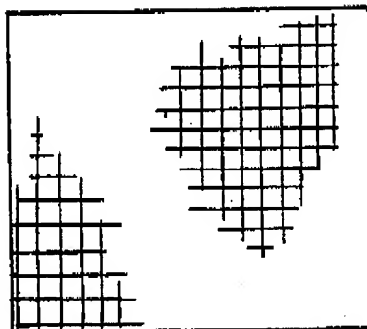


FIG. 19B

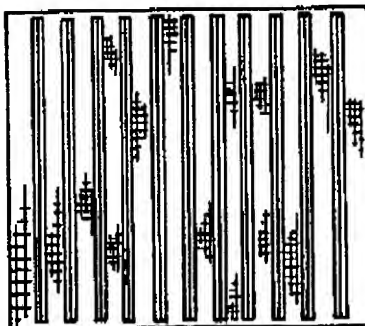
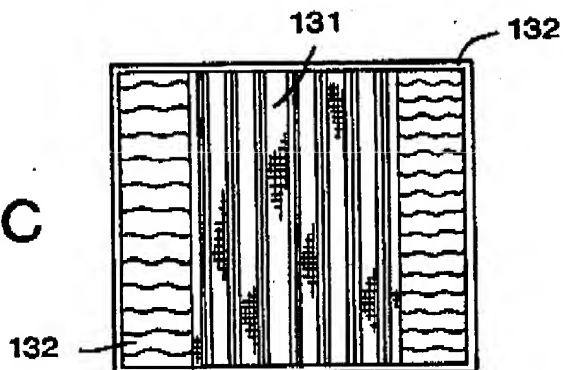


FIG. 19C



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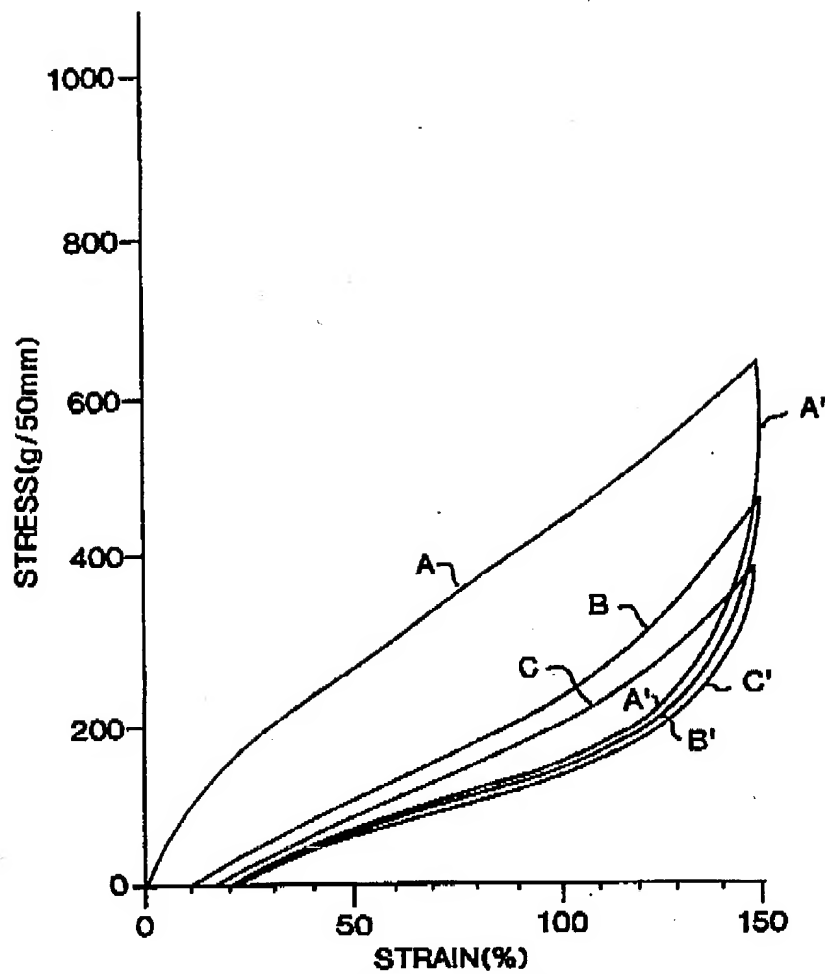


FIG. 20

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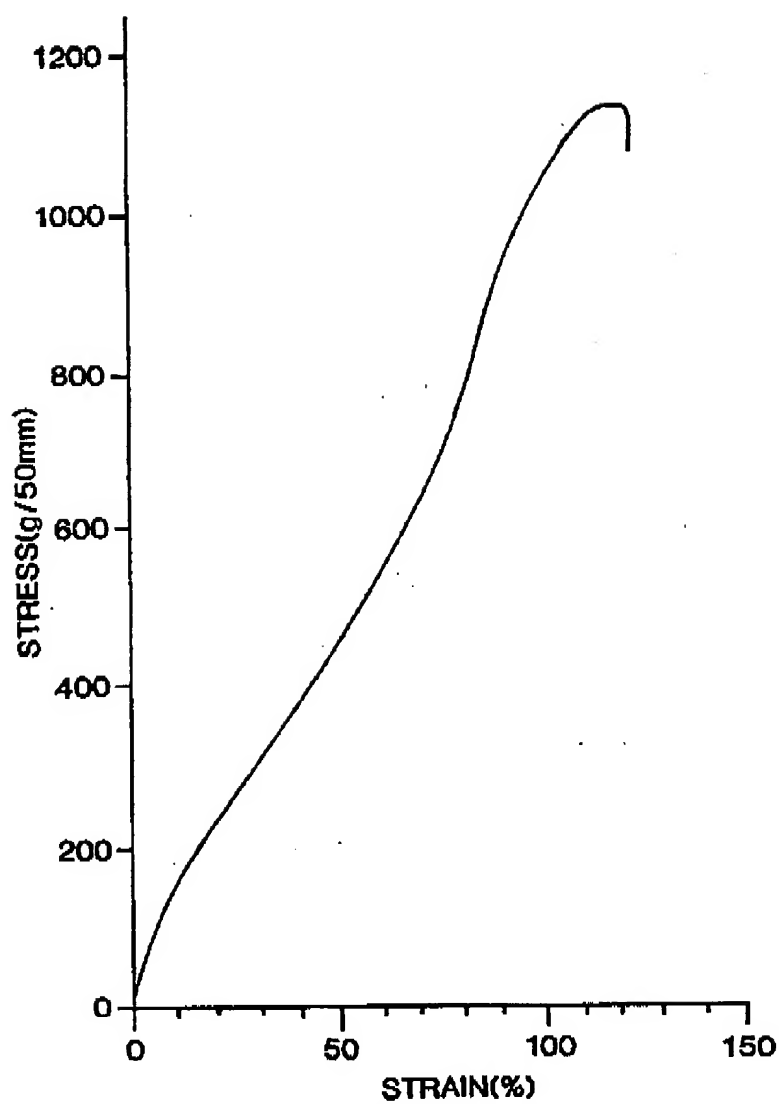


FIG. 21

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/00505

A. CLASSIFICATION OF SUBJECT MATTER IPC(G) :B32B 3/10, 3/12; A61F 13/15 US CL :428/152; 163, 198, 284, 299; 604/317, 365 According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) U.S. : 428/152, 163, 198, 284, 299; 604/317, 365 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched NONE Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) NONE		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 4,720,415 (VANDER WIELEN ET AL.) 19 January 1988, see entire document.	1-19
A	US, A, 4,652,487 (MORMAN) 24 March 1987, see entire document.	1-19
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be part of particular relevance "E" earlier document published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to underpin the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "A" document member of the same patent family		
Date of the actual completion of the international search 03 APRIL 1995		Date of mailing of the international search report 04 MAY 1995
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230		Authorized officer <i>Blaine R. Copenhaver</i> BLAINE R. COPENHAVER Telephone No. (703) 308-2351

Form PCT/ISA/210 (second sheet)(July 1992)*